Claims

1. A noise shaping arrangement for a phase locked loop, the arrangement comprising:
a first order sigma-delta modulator (500) arranged to provide a first-order quantized output and a feedback path output (508);
a second order sigma-delta modulator (520) coupled to receive the feedback path output (508) from the first order sigma-delta modulator (500) and arranged to provide a second order quantized output; and
combination means (530) arranged to combine the first and second order quantized outputs to provide a combined third order quantized output (540),
wherein the combined third order output provides noise shaping with a frequency notch spectrum.

2. The arrangement of claim 1 wherein the second order sigma-delta modulator is arranged with one or more complex conjugate pairs of zeros (270, 275).

3. The arrangement of claim 2 wherein the one or more complex conjugate pairs of zeroes (270, 275) is located on the unity circle.

4. The arrangement of claim 2 or 3 wherein the one or more complex conjugate pairs of zeroes (270, 275) is located away from the real axis.

5. The arrangement of claim 4 wherein the frequency location of the one or more complex pair of zeros is a

selected one of substantially 365kHz and substantially 518kHz.

5. The arrangement of any preceding claim where the feedback path output of the first order sigma-delta modulator received by the second order sigma-delta modulator is scaled (521) by a factor of substantially one quarter and wherein accumulators of the first order (504) and second order (522) sigma-delta modulator respectively have the same bit-size.

6. The arrangement of any preceding claim, further comprising a delay block (506) coupled between the feedback output of the first order sigma-delta modulator and the combination means.

7. The arrangement of any preceding claim wherein the combination means (530) includes scaling means (532, 534) coupled to scale the second order quantized output of the second order sigma-delta modulator by a predetermined scaling factor.

8. The arrangement of claim 7 wherein the predetermined scaling factor is substantially 2^{-22}.

9. The arrangement of any preceding claim wherein the second order sigma-delta modulator (520) is operable to cancel the quantisation noise of the first order sigma-delta modulator (500).

10. The arrangement of any preceding claim wherein the feedback path output comprises a quantisation noise of the first order sigma-delta modulator (500).

11. The arrangement of any preceding claim wherein the frequency notch spectrum comprises at least one non-DC frequency notch.

12. The arrangement of any preceding claim wherein the second order sigma-delta modulator (520) comprises a loop arrangement having a forward processing block (420) implementing the transfer function given by the z-transform:

$$\frac{z^{-1}}{1-2z^{-1}\cos\theta+z^{-2}}$$

and a feedback processing block (450) implementing the function given by the z-transform:

$$2\cos\theta-z^{-1}$$

where

$$\theta=2\pi\frac{f}{f_s}$$

and f is the desired notch frequency and f_s is the sample frequency.

13. A phase locked loop incorporating the noise shaping arrangement of any preceding claim.

14. A method for noise shaping in a phase-locked loop, the method comprising the steps of:
providing a first order quantized output from a first order sigma-delta modulator (500);
providing a second order quantized output from a second order sigma-delta modulator (520) coupled to receive a feedback path output (508) from the first sigma-delta modulator (500);
combining (530) the first and the second order quantized outputs to provide a combined third order quantized output (540),
wherein the combined third order output provides noise shaping with a frequency notch spectrum.

15. The arrangement, phase locked loop or method of any preceding claim wherein the phase locked loop is a fractional-n phase locked loop frequency synthesizer.